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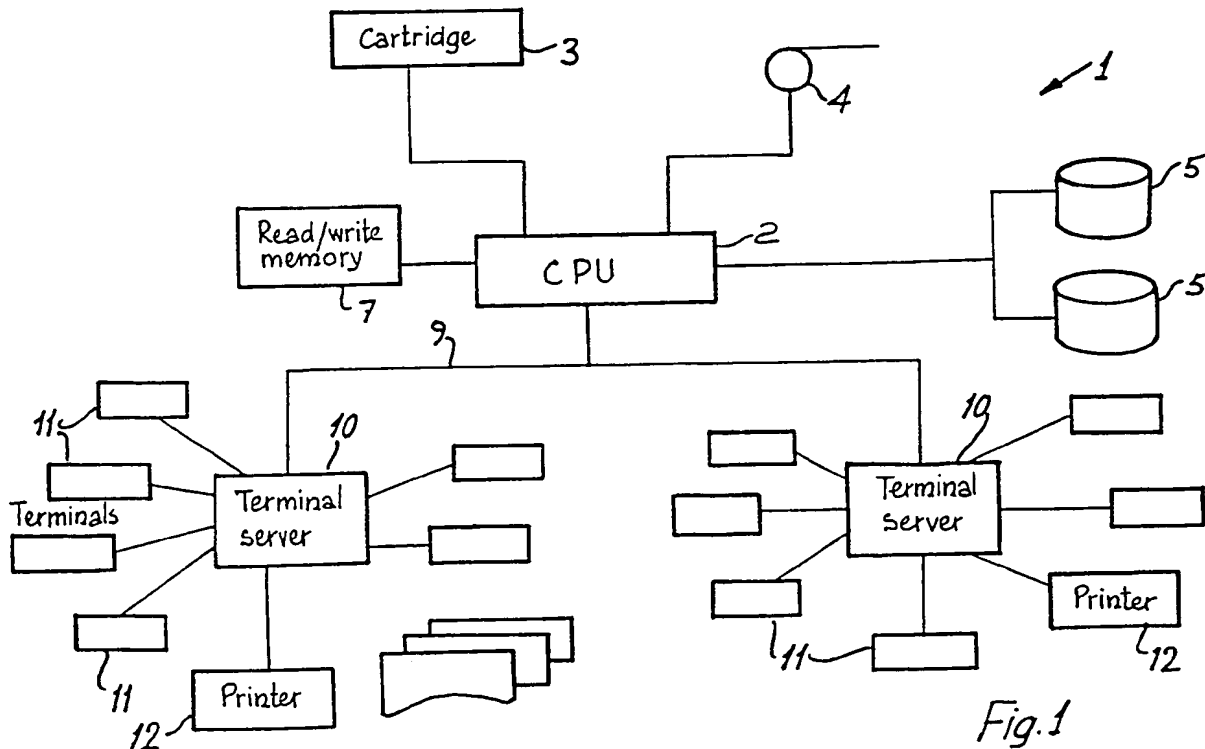
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GB 1262927 A EP 0198402 A2 US 4920488 A
US 4796209 A

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INT CL⁵ B65G, G06F
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(54) A warehouse control apparatus

(57) A warehouse control apparatus (1) is disclosed which includes a CPU (2) which directs storage in disk drives (5) of data including vacant time and actual storage times for storage locations on racks of a warehouse. A map of the warehouse is stored in the disk drives (5) and the CPU (2) generates a list of storage locations for incoming pallets. A storage location is eligible if it is vacant and if it matches the height and weight attributes of the pallet and if the sum of the time it has been vacant and the time it was previously occupied is not less than the estimated rack life of the incoming pallet. Where there is more than one eligible storage location for a pallet, the one which will require the least vehicle time to store and retrieve the pallet is selected.



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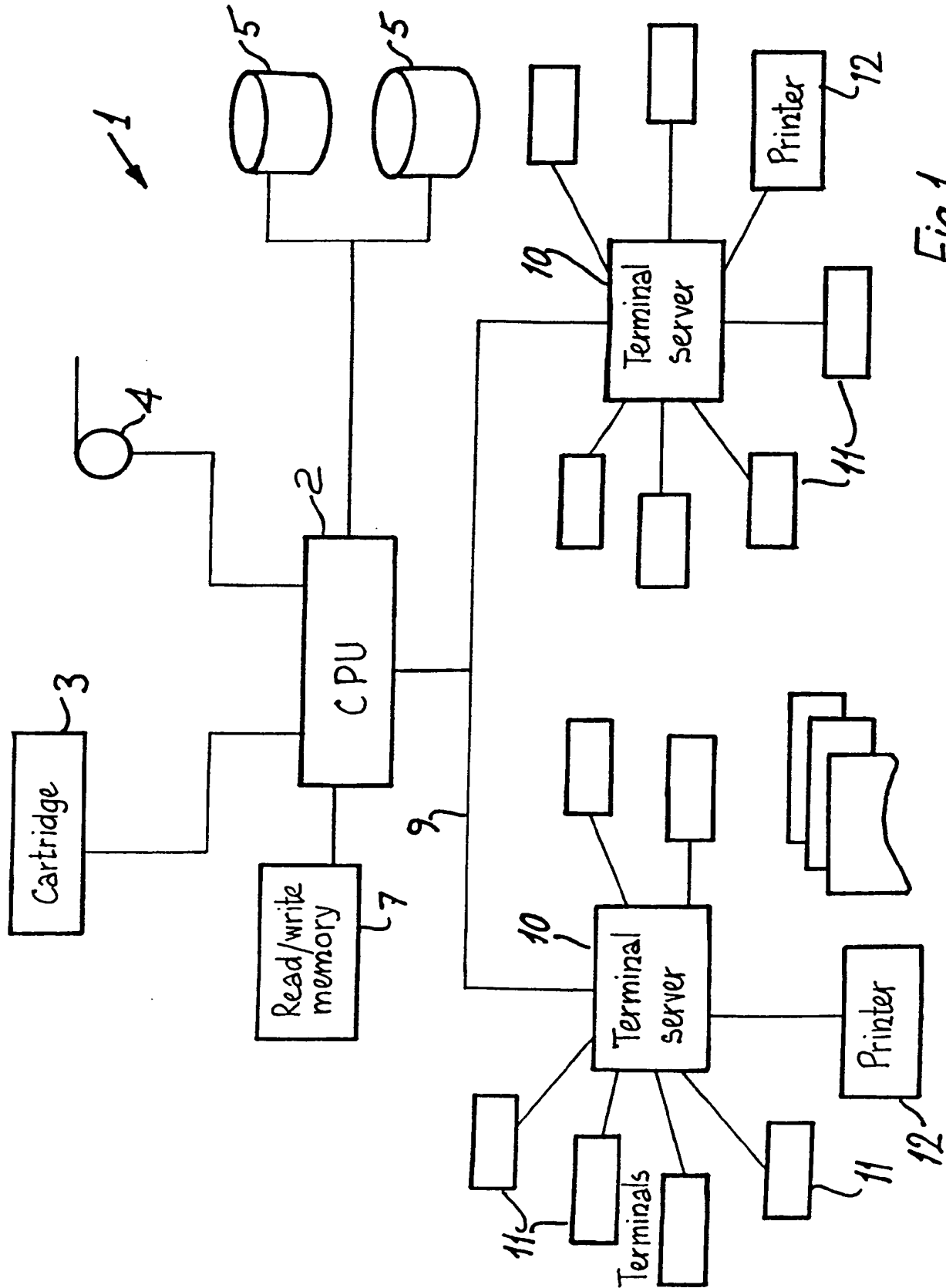


Fig. 1

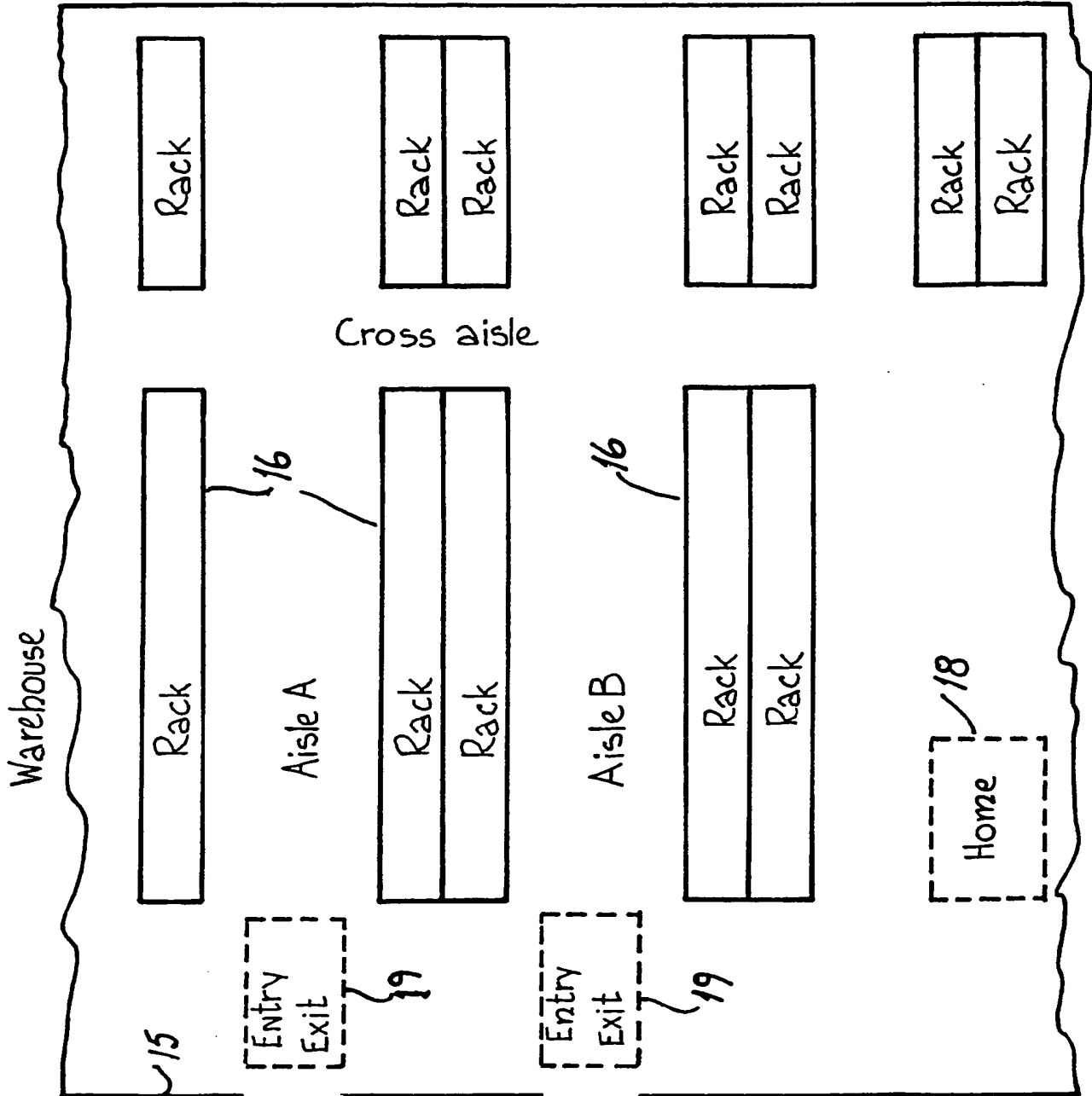


Fig. 2

- 1 -

" A Warehouse Control Apparatus"

The present invention relates to a warehouse control apparatus for controlling the storage and retrieval of articles.

One of the most important operations in manufacturing or distribution companies is the storage and retrieval of articles in an efficient and timely manner. If this is not achieved, production or distribution orders may be lost. Various systems have been developed to control operations of a warehouse such as those described in US Patent Specification No.'s 4,920,488 (Filley) and 4,796,209 (Allegheny). These systems use relatively complex optical readers to generate geographical data for articles within a warehouse. While these systems may be useful for identifying the location of a desired stored article, they are not particularly useful in identifying ideal vacant storage locations for storage of the articles to reduce costs and improve efficiency of warehouse operations generally.

An object of the present invention is to provide a warehouse control apparatus which identifies the vacant storage locations suitable for storage of received articles to improve the efficiency of the retrieval and storage of the articles.

Another object is to provide information for the retrieval of articles. A further object is to generate reports which assist in the management of warehouse operations.

According to the invention, there is provided a warehouse
5 control apparatus comprising a host processing unit connected by a local area network to terminal servers to which terminals are connected in a star configuration, the host processing unit being connected directly to fixed disk drives, a back-up
tape drive, a printer, and to a read/write memory circuit,
10 wherein the host processing unit is operable to generate a warehouse location control signal by performing the steps of:-

directing storage in a fixed disk of a warehouse map of storage and picking locations for articles and handling locations for vehicles including entry, and home handling
15 locations for vehicles and of estimated times for vehicle manoeuvre routes in the warehouse;

storing on a fixed disk storage data relating to occupancy of the storage locations including details of articles stored in them, and, for each occupied location,
20 values for the actual and estimated rack life of the stored article, and, for each vacant storage location, values for the time during which it has been vacant and the time during which it was previously occupied;

incrementing the time each storage location has been vacant and the actual rack life of each stored article on receipt of an instruction signal from a terminal;

5 storing on a fixed disk data relating to incoming orders for articles and determining, according to values for incoming quantity, demand and the quantity in storage, an estimated rack life for each incoming article;

10 matching in the read/write memory circuit each of a set of vacant storage locations available to receive incoming articles to each of a class of incoming article in turn by seeking the first article with an estimated rack life equal to or less than the sum of the vacant time and the previous occupancy for the storage location;

15 selecting, where a match has been established, the storage location which yields a lesser time value for a vehicle to perform the operation of storing and retrieving the article; and

transmitting a signal indicating the selected candidate to the local network for output to a user.

20 In one embodiment, the host processing unit comprises means for sorting storage data according to article class and generating a report showing for each class of articles the

storage locations occupied in the order in which the articles are to be retrieved according to expiry date and estimated rack life, or date received and estimated rack life.

Preferably, the host processing unit comprises means for
5 transmitting a signal indicating the set of candidate vacant storage locations to a terminal of the local area network.

The invention will be more clearly understood from the following description of some preferred embodiments thereof, given by way of example only with reference to the
10 accompanying drawings in which:-

Fig. 1 is a schematic outline of the warehouse control apparatus of the invention;

Fig. 2 is a schematic outline of a warehouse.

Referring to the drawings, and initially to Fig. 1, there is
15 illustrated a warehouse control apparatus of the invention, indicated generally by the reference numeral 1. The apparatus 1 comprises a host processing unit, namely, a CPU 2, which in this embodiment is a MICROVAX 3900 CPU. The CPU 2 is connected to a 300 Mbyte cartridge 3 and to a 1600 BPI tape
20 drive 4. For storage of data, the CPU 2 is connected to a pair of 600 Mbyte disk drives 5. The CPU 2 is connected to a batch printer 6 and to a read/write memory circuit 7. A real-

time clock is incorporated in the CPU 2. To carry out a wide variety of data processing functions, the CPU 2 is connected in a local area network 9 which includes two terminal servers 10, each of which is connected to up to 33 terminals 11 and to a printer 12.

Referring now to Fig. 2, there is illustrated a portion of a warehouse 15, the operations of which are controlled by the apparatus 1. The warehouse 15 includes 4,000 storage locations, each for storage of articles, namely, pallets of goods. The storage locations are on racks 16 which are 1 storage location deep and 4 or 5 locations high. The racking provides four or five levels of storage and two beam ratings - 2,500 and 3,000 KG. Each storage location is classified according to the height and weight of pallet which it can 15 accommodate. The racking is arranged back to back in aisles with openings to provide cross aisles. Each product is assigned a fixed picking location at floor level. The warehouse 15 includes a "home" base 18 for retrieval vehicles for handling pallets. Other handling locations include 20 entry/exit locations 19.

In the apparatus 1, the disk drives 5 store data which is input via terminals connected to the servers 10 or via serial interfaces at the CPU 2. A warehouse map similar to that illustrated in Fig. 2 is stored in a fixed disk drive 5 and 25 the map includes distances including lengths of aisles, widths

of aisles and details of all pathways in which vehicles may travel. Details of all storage and handling locations are also stored, each of which has an identification number. In addition, pre-set times for laden and unladen vehicle
5 manoeuvres are stored.

Further, storage data relating to occupancy of the storage locations is also stored in a fixed disk drive 5. This storage data includes details of the pallets including a
10 each pallet is packed including the height and weight classification of a pallet of that product and whether this product is to be issued in expiry date or receipt date order. For each storage location which is occupied, there is stored a value for the actual rack life of the stored pallet i.e. the
15 length of time during which the pallet has been stored. The received date is also stored. For each vacant storage location, the time during which the location has been vacant is stored, together with the actual rack life for the article previously stored in that location.

20 Once all of this data has been stored initially in the fixed disk drives 5, it is regularly updated in two ways. Firstly, on receipt of user instructions, each day the CPU updates the time values provided the situation has not changed since the previous day. For example, the actual rack life for an
25 article in a storage location is incremented by one day

provided it has not been removed during the previous day and similarly, the vacant time for a storage location is incremented by a day provided it has not been used during the previous day. The other way in which the data is updated is
5 by reception of storage data at the terminals. As pallets are stored and removed from the locations, the relevant information is recorded at the terminals and is stored in the disk drives 5.

The terminals which are located in offices dealing with
10 delivery and orders for articles receive data relating to orders and demands generally for the articles. The delivery dates for (received) articles are also recorded at these terminals.

Pallets are received in container loads corresponding to
15 purchase orders on suppliers. A container load consists of up to sixty pallets of one or more products. The details of this load are already recorded and have already been printed out on a worksheet with a line for each pallet. The apparatus 1 generates a display of vacant storage locations for one
20 container at a time and an operator notes these locations on the worksheets. The operator has the option to manually override the computer allocation. The storage location is also printed on a label for fixing to each pallet. If a product is out of stock the CPU 2 will allocate the first
25 pallet directly to the picking location.

The worksheets are then used to check the contents of the containers as they are unloaded at the entry location. The operator records any shortages, overages or damage, and any expiry dates on the worksheet. Finally, the operator records
5 these details of shortages and dates through a terminal and at the same time confirms the storage locations used.

To generate these outputs, the CPU 2 creates a list in the read/write memory 7 of all vacant locations. The particular entry/exit handling location 19 for receipt of the pallets is
10 also recorded. To generate a list of suitable vacant locations for the pallets, the CPU 2 processes pallets for each product in turn. An estimated rack life for each pallet is determined. The estimated rack life is based on the stock on hand, the quantity per pallet and the known daily demand
15 for the product. The estimated rack life for each succeeding pallet of a product is equal to or greater than the previous one. The CPU 2 then carries out processing operations to match vacant storage locations to the list of pallets for each product. It commences with vacant storage locations in the
20 aisle containing the picking location and thereafter, aisles on each side. It ignores vacant locations which do not match the height and weight requirements of the product. For vacant locations which do meet the requirements it sums the days the location has been vacant and the days it was previously
25 occupied and compares this sum to the estimated rack life for each pallet of the product. If the estimated rack life of a

pallet is equal to or less than the sum, this is an eligible storage location for the pallet, in other words, if the following equation is satisfied:

$$\text{ERL} \leq \text{Vacant time} + \text{ARL for previously stored pallet},$$

- 5 then that vacant storage location is identified as a candidate for storage of the received pallet.

The reason for carrying out these operations is to allocate a pallet with a short rack life to a storage location close to its picking location and to allocate a pallet with a longer
10 rack life to a storage location which may be further away. There is a saving in handling costs by doing this. The storage locations immediately above the main picking areas have to be shared by any "fast moving" pallets for all the products picked in that area, thus the method used in effect
15 reserves vacant storage locations for these other products without reserving specific storage locations for specific products or for pallets with a specific rack life. The apparatus dynamically adjusts to changing patterns by incrementing the eligibility threshold for a storage location
20 each day. This threshold is initially set to the number of days it was previously occupied.

When the CPU 2 has matched a pallet of the product to an eligible storage locations, it calculates the time it will

take the retrieval vehicle (fork lift truck) to store and retrieve the pallet. The storage operation is based on the fork lift truck being driven unladen from the home location to the entry location, then carrying the pallet to the storage
5 location and lifting it up, and then returning to the home position. The retrieval operation is based on the fork lift truck being driven unladen from the home position to the storage location, then lifting down the pallet and carrying it to its picking location, and then returning to the home
10 location. This time and the storage location are stored in the list entry for the matching pallet and the list entry for the vacant storage location is marked as allocated. The CPU 2 matches each unallocated vacant location in its list to the list of pallets for one product. When an alternative storage
15 location is found for a pallet, the timings of the two candidates are compared. The storage location with the lesser time is used for that pallet and the one with the greater time is matched against the remaining pallets in the list. The list of pallets is in ascending order by estimated rack life.
20 When all of the vacant storage locations have been checked against the pallets for one product, this process is repeated for the next product until all the pallets in the container have been allocated storage.

The CPU 2 may direct transmission at a radio transmitter of
25 this data for reception by radio receivers at each of the vehicles and subsequent display of the data for viewing by a

driver. Generally, the CPU 2 sorts the information which is transmitted into a list of pallet handling requests by driver based on a system of priorities and optimisation.

5 In practice, while the information provided by the apparatus of the invention is extremely useful, there are situations when the automatically generated allocations should not be adhered to, for example when the data used to calculate the estimated rack life of incoming pallets or the history of the vacant storage location need to be qualified.

10 The operator can substitute a vacant storage location of his own choosing for that allocated by the computer to overcome these problems without loss of efficiency. This is an extremely important aspect of the invention, as an ideal balance is achieved between efficiency and consistency in
15 storage of data while at the same time allowing for unforeseen and unusual circumstances in a versatile and efficient manner. One exception which is considered by the CPU 2 in determining storage locations is where the estimated rack life is one day or less and the picking location is vacant, in which case the
20 CPU 2 does not carry out the normal selection process and directs storage of the pallet in the picking location 17, thus circumventing the usual handling process.

In addition to directing storage and retrieval of pallets, the apparatus 1 also generates reports which provide information

on the storage of articles. Portion of such a report is as follows:-

PRODUCT	DESCRIPTION	PACK	CASES
3610802	Product X	12	96

5	LOCATION	EXPIRY DATE	RECEIVED	ERL	ARL
	8250-P	1/6/91	27/09/90	18	13
	8333-S	1/5/91	18/09/90	12	20
	8441-S	1/6/91	27/09/90	22	13
10	8483-S	1/6/91	27/09/90	26	13

The pallets are removed to replenish the picking location in the same order that they are listed here. The first line shows the last pallet moved to the picking location because of its earlier expiry date. The next three pallets were received in the same consignment and have the same actual rack life. They are listed in order of estimated rack life so that the pallet nearest to the picking location is used first as intended by the apparatus when it allocated this storage to location to this pallet.

It will thus be appreciated that the invention provides a simple and effective apparatus for control of warehouse operations in an efficient manner.

The invention is not limited to the embodiments hereinbefore described, but may be varied in construction and detail.

CLAIMS

1. A warehouse control apparatus comprising a host
processing unit connected by a local area network to
terminal servers to which terminals are connected in a
5 star configuration, the host processing unit being
connected directly to fixed disk drives, a back-up tape
drive, a printer, and to a read/write memory circuit,
wherein the host processing unit is operable to generate
a warehouse location control signal for performing the
10 steps of:-

directing storage in a fixed disk of a warehouse map
of storage and picking locations for articles and
handling locations for vehicles including entry, and
home handling locations for vehicles and of
15 estimated times for vehicle manoeuvre routes in the
warehouse;

storing on a fixed disk storage data relating to
occupancy of the storage locations including details
of articles stored in them, and, for each occupied
20 location, values for the actual and estimated rack
life of the stored article, and, for each vacant
storage location, values for the time during which
it has been vacant and the time during which it was
previously occupied;

incrementing the time each storage location has been vacant and the actual rack life of each stored article on receipt of an instruction signal from a terminal;

5 storing on a fixed disk data relating to incoming orders for articles and determining, according to values for incoming quantity, demand and the quantity in storage, an estimated rack life for each incoming article;

10 matching in the read/write memory circuit each of a set of vacant storage locations available to receive incoming articles to each of a class of incoming article in turn by seeking the first article with an estimated rack life equal to or less than the sum of
15 the vacant time and the previous occupancy for the storage location;

selecting, where a match has been established, the storage location which yields a lesser time value for a vehicle to perform the operations of storing
20 and retrieving the article; and

transmitting a signal indicating the selected candidate to the local network for output to a user.

2. An apparatus as claimed in claim 1, wherein the host processing unit comprises means for sorting storage data according to article class and generating a report showing for each class of articles the storage locations occupied in the order in which the articles are to be
5 retrieved according to expiry date and estimated rack life, or date received and estimated rack life.
3. An apparatus as claimed in any preceding claim, wherein the host processing unit comprises means for transmitting
10 a signal indicating the set of candidate vacant storage locations to a terminal of the local area network.
4. An apparatus substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

CLAIMS

1. A warehouse control apparatus comprising a host
processing unit connected by a local area network to
terminal servers to which terminals are connected in a
star configuration, the host processing unit being
connected directly to fixed disk drives, a back-up tape
drive, a printer, and to a read/write memory circuit,
wherein the host processing unit is operable to generate
a warehouse location control signal by performing the
steps of:-

directing storage in the fixed disk drives of a
warehouse map of storage and picking locations for
articles and handling locations for vehicles
including entry, and home handling locations for
vehicles and of estimated times for vehicle
manoeuvre routes in the warehouse;

directing storage in the fixed disk drives of
storage data relating to occupancy of the storage
locations including details of articles stored in
them, and, for each occupied location, values for
the actual and estimated rack life of the stored
article, and, for each vacant storage location,
values for the time during which it has been vacant

and the time during which it was previously occupied;

5 incrementing the time each storage location has been vacant and the actual rack life of each stored article on receipt of an instruction signal from a terminal;

10 directing storage in the fixed disk drives of data relating to incoming orders for articles and determining, according to values for incoming quantity, demand and the quantity in storage, an estimated rack life for each incoming article;

15 matching in the read/write memory circuit each of a set of vacant storage locations available to receive incoming articles to each of a class of incoming articles in turn by seeking the first article with an estimated rack life equal to or less than the sum of the vacant time and the previous occupancy for the storage location;

20 selecting, where a match has been established, the storage location which yields a lesser time value for a vehicle to perform the operations of storing and retrieving the article;

transmitting a signal indicating the selected storage location to the local network for output to a user; and

5 transmitting a signal indicating the set of candidate vacant storage locations to a terminal of the local area network.

2. An apparatus as claimed in claim 1, wherein the host processing unit comprises means for sorting storage data according to article class and generating a report
10 showing for each class of articles the storage locations occupied in the order in which the articles are to be retrieved according to expiry date and estimated rack life, or date received and estimated rack life.
3. An apparatus substantially as hereinbefore described with
15 reference to and as illustrated in the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under
Section 17 (The Search Report)

-19 - Application number 9028143.7

Relevant Technical fields

(i) UK Cl (Edition K) B8W (WC) G4A (AUD)

(ii) Int Cl (Edition 5) G65G G06F

Search Examiner

D J LOVELL

Databases (see over)

(i) UK Patent Office

(ii) ON-LINE DATABASE - DERWENT WPI

Date of Search

25 APRIL 1991

Documents considered relevant following a search in respect of claims

1 to 4

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	GB-1262927 (WESTINGHOUSE) (Note eg apge 10 lines 46-50)	1
A	EP 0198402 A2 (F KRUPP GES) (Note English translation under Section 77(6)(a), page 5, paragraph 2)	1
A	US 4920488 (FILLEY)	1
A	US 4796209 (BURK)	1

SF2(p)

E65ABO

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

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